

What is claimed is:

1. A collimating device comprising:

5 a first transparent substrate having a first surface and a second surface, the first transparent substrate having an index of refraction;

a plurality of wave guide structures provided in the first transparent substrate, the plurality of wave guide structures having an index of refraction different than the index of refraction of the first transparent substrate, each wave guide structure having a base associated with the first surface of the first transparent substrate;

10 a second transparent substrate having a first surface and a second surface wherein the first surface of the second transparent substrate is facing the first surface of the first transparent substrate, the second transparent substrate having an index of refraction; and

15 a plurality of exit control structures provided in the second transparent substrate, the plurality of exit control structures having an index of refraction different than the index of refraction of the second transparent substrate, each exit control structure having a base associated with the first surface of the second transparent substrate;

20 wherein the first surface of the first transparent substrate and the first surface of the second transparent substrate face each other such that each wave guide structure is generally aligned with each exit control structure thereby forming a collimating structure,

wherein light emanating from a first direction facing the second surface of the first transparent substrate is collimated as it exits adjacent collimating structures.

25 2. The device of claim 1 wherein each respective base of the plurality of wave guide structures is contiguous with each respective base of the plurality of exit control structures.

30 3. The device of claim 1 wherein the generally aligned wave guide and exit control structures are spaced apart from each other defining apertures therebetween and are generally aligned parallel to each other.

4. The device of claim 1 wherein the index of refraction of the first transparent substrate is generally the same as the index of refraction of the second transparent substrate.

5 5. The device of claim 4 wherein the first and second transparent substrates are constructed of a polymer.

6. The device of claim 5 wherein the index of refraction of the wave guide structure is generally the same as the index of refraction of the exit control structure.

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7. The device of claim 6 wherein the index of refraction of the wave guide and exit control structures is less than the index of refraction of the first and second transparent substrates.

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8. The device of claim 7 wherein the wave guide and exit control structures are defined by voids in the first and second transparent substrates, respectively.

9. The device of claim 8 wherein voids are filled with air.

10. The device of claim 8 wherein voids are filled with a metal.

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11. The device of claim 1 wherein the plurality of wave guide structures each include a triangular cross-section having a base and a pair of sidewalls.

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12. The device of claim 11 wherein the plurality of exit control structures each include a truncated isosceles triangular cross-section having a major base, a minor base, and a pair of sidewalls.

13. The device of claim 12 wherein the sidewalls of the wave guide structures are at an angle relative to the first surface of the first transparent substrate sufficient to reflect light striking the wave guide structure from the first direction.

5 14. The device of claim 13 wherein the angle of each sidewall is between about 76 degrees and less than 90 degrees.

15. The device of claim 11 wherein each of the plurality of wave guide structures have an aspect ratio of between about 2 and about 22.

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16. The device of claim 12 further comprising a reflective material provided on the minor base of the exit control structure having a truncated isosceles triangular cross-section.

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17. The device of claim 16 wherein the reflective material is configured to reflect light impingent thereon from a second direction opposite the first direction, and the plurality of collimating structures are configured to transmit light arriving from the first direction, wherein the sum of the percent of light being reflected relative to the light coming from the second direction, and the percent of light being transmitted relative to the amount of light coming from the first direction, is greater than 100 percent.

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18. A light control device comprising:

a first light transmissive film comprising a first plurality of light reflecting regions extending into a surface thereof; and

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a second light transmissive film disposed adjacent the first light transmissive film and comprising a second plurality of light reflecting regions extending into a surface thereof,

wherein the first plurality of light reflecting regions and the second plurality of light reflecting regions are relatively positioned such that light entering the device is collimated as it exits the device.

19. The device of claim 18, wherein the first plurality of light reflecting regions comprises a plurality of grooves.
20. The device of claim 18, wherein the first and second plurality of light reflecting regions
5 each comprise a plurality of grooves.
21. The device of claim 20, wherein the first and second plurality of light reflecting regions are mutually aligned.
- 10 22. The device of claim 18, wherein the first and second light transmissive films are substantially refractive index matched.
23. The device of claim 18, wherein the first and second light transmissive films are laminated together.
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24. The device of claim 18, wherein the first and second light transmissive films are bonded together using an optical adhesive.
25. The device of claim 18, wherein the first plurality of light reflecting regions exhibit a
20 index of refraction that is less than the refractive index of the first light transmissive film.
26. A process for making a light control device comprising the steps of:
forming a first light transmissive film having a first plurality of indentations
extending into a surface thereof;
25 forming a second light transmissive film having a second plurality of indentations
extending into a surface thereof;
rendering the first and second plurality of indentations light reflecting; and
adjacently disposing the first and second light transmissive films, wherein the

first and second plurality of indentations are relatively positioned such that light entering the device is collimated after it exits the device.

5 27. The process of claim 26, further comprising the step of mutually aligning the first and second plurality of indentations.

10 28. The process of claim 26, wherein the step of rendering the first and second plurality of indentations light reflecting comprises filling the first and second plurality of indentations with a material having an index of refraction less than the index of refraction of the first and second light transmissive films.

15 29. The process of claim 26, wherein the step of adjacently disposing the first and second light transmissive films comprises laminating the first and second light transmissive films together.

30. The process of claim 29, wherein laminating is performed using an optical adhesive.

20 31. The process of claim 26, wherein the step of rendering the first and second plurality of indentations light reflecting is performed before the step of adjacently disposing the first and second light transmissive films.

25 32. The process of claim 26, wherein the step of rendering the first and second plurality of indentations light reflecting is performed after the step of adjacently disposing the first and second light transmissive films.

33. An LCD display comprising:
a backlight assembly;
a collimating device provided adjacent the backlight assembly, the collimating device including:

a transparent substrate having a first surface and a second surface,
the transparent substrate having an index of refraction;

a plurality of wave guide structures provided in the transparent
substrate adjacent the first surface of the transparent substrate, the
5 plurality of wave guide structures having an index of refraction different
than the index of refraction of the transparent substrate, each wave guide
structure having a base;

a plurality of exit control structures provided in the transparent
substrate adjacent the second surface of the transparent substrate, the
10 plurality of exit control structures having an index of refraction different
than the index of refraction of the transparent substrate, each exit control
structure having a base, the plurality of wave guide structures being
generally aligned with the plurality of exit control structures such that
each respective wave guide structure base is associated with each
15 respective exit control structure base; and

a liquid crystal suspension containing pixels therein; and

a reflective layer adjacent the pixels, the reflective layer having apertures therein.

34. The LCD display of claim 33 wherein the generally aligned wave guide and exit control
20 structures are spaced apart from each other defining apertures therebetween, wherein the
apertures between the reflective layer are generally aligned with the apertures between
the wave guide and exit control structures.

35. An LCD display comprising:

25 an LCD module;

a backlight assembly;

a wave guide provided adjacent the backlight assembly, the wave guide including:

a transparent substrate having a first surface and a second surface,
the transparent substrate having an index of refraction, the transparent

substrate permitting light arriving from a first direction to enter the first surface, transmit through the transparent substrate, and exit the second surface;

5 a plurality of wave guide structures provided in the transparent substrate adjacent the first surface of the transparent substrate, the plurality of wave guide structures having an index of refraction different than the index of refraction of the transparent substrate; and

10 a reflective layer provided in the LCD module separately and distinctly from the wave guide; the reflective layer configured to reflect light arriving from a second direction, the second direction being opposite the first direction, wherein the sum of the percentage of light being transmitted relative to the amount of light coming from said first direction and the percentage of light being reflected relative to the amount of light coming from said second direction, is greater than 100 percent.

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